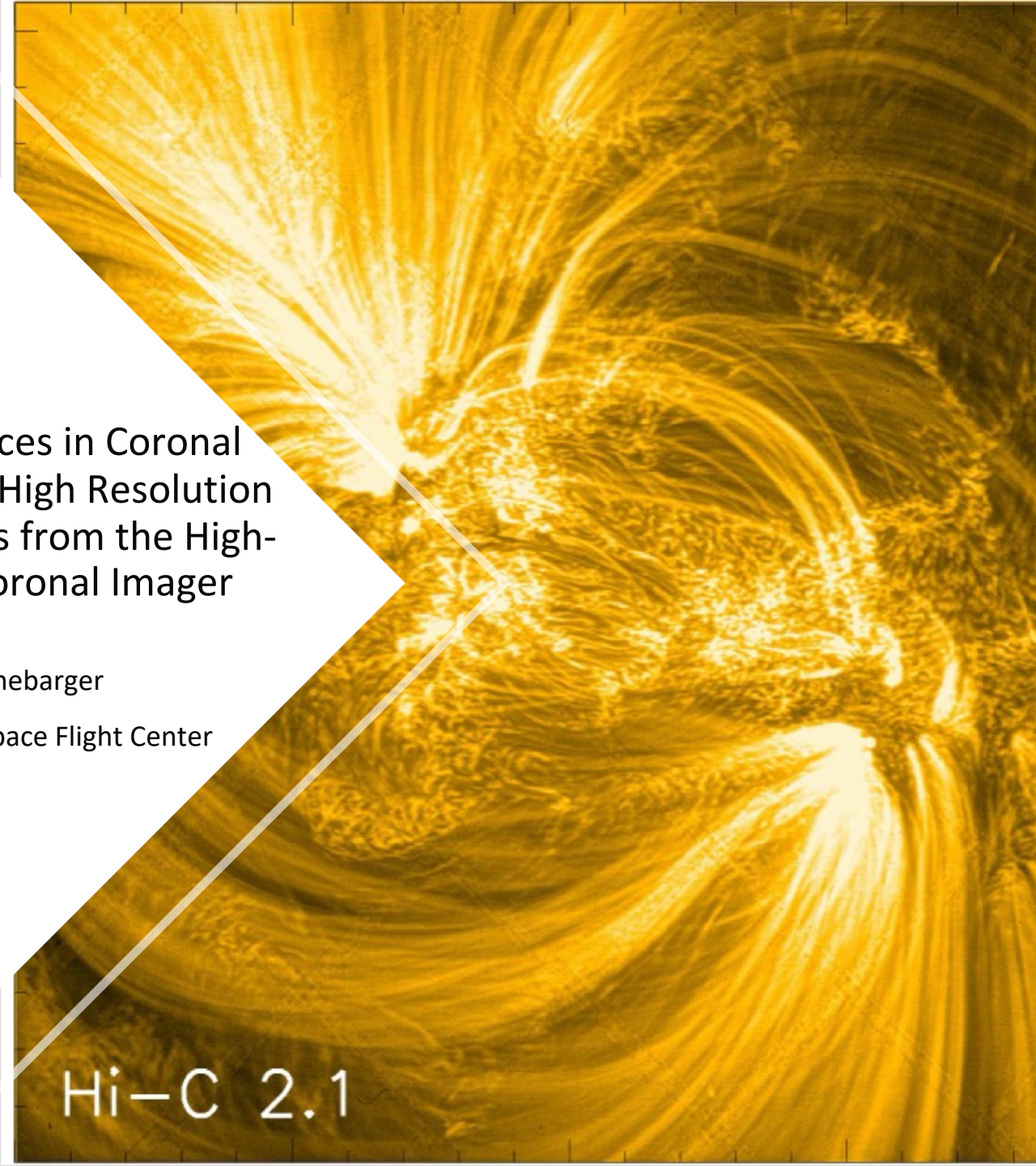
Recent advances in Coronal Heating due to High Resolution Imaging: Results from the High-Resolution Coronal Imager

Amy Winebarger

NASA Marshall Space Flight Center

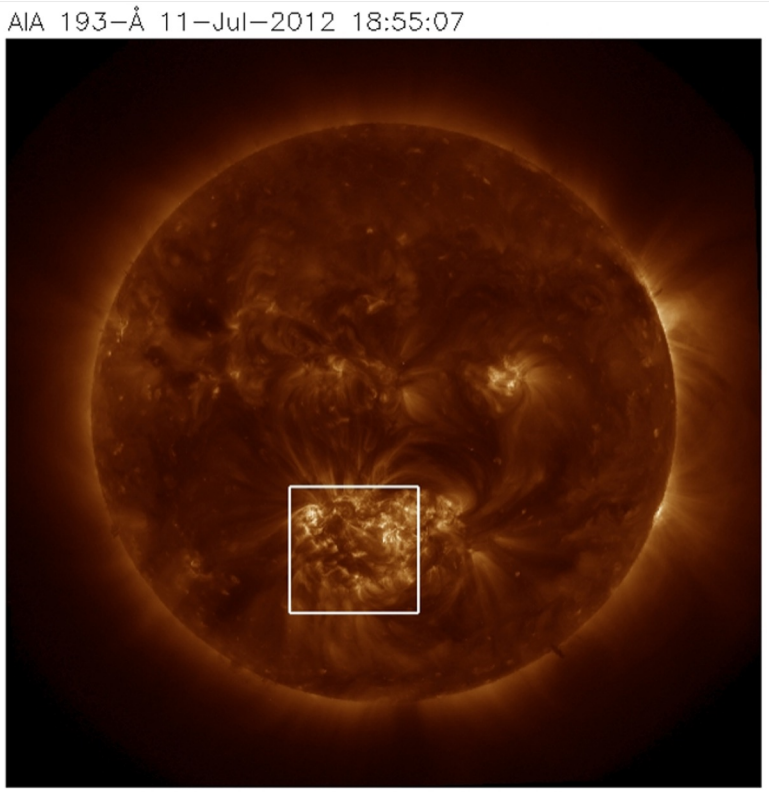


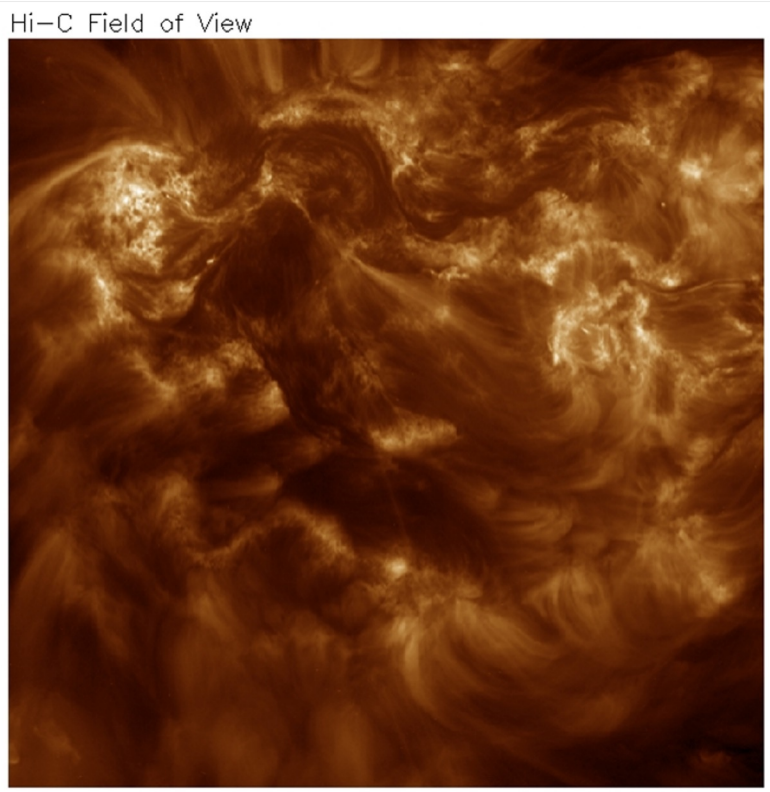
What is a sounding rocket?

- Rocket flown to make a scientific measurement
- Used to develop and test instrumentation, access unique scientific regions, and train the next generation

What is the High-resolution Coronal Imager (Hi-C)?

- Hi-C 1 (Cirtain)
  - Flew in 2012
  - 193 passband
- Hi-C 2 (Cirtain)
  - Flew in 2016
  - 172 passband
  - Unsuccessful
- Hi-C 2.1 (Winebarger)
  - Flew in 2018
  - 171 passband
- Hi-C Flare (Savage)
  - To be flown March 2024
  - 128 passband
  - Additional instruments added





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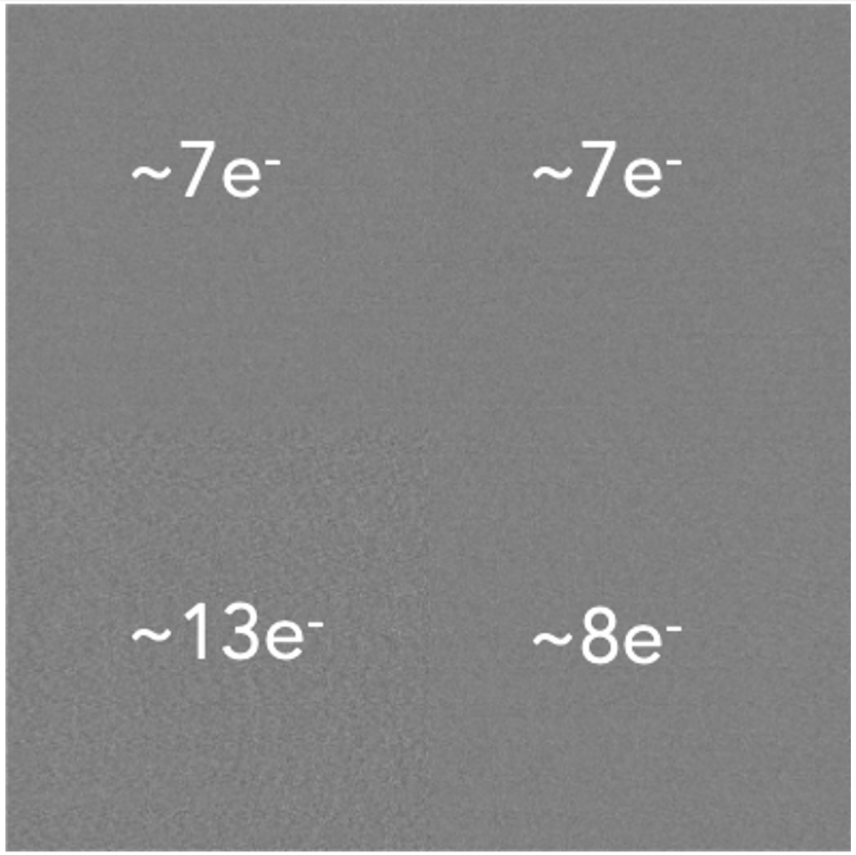

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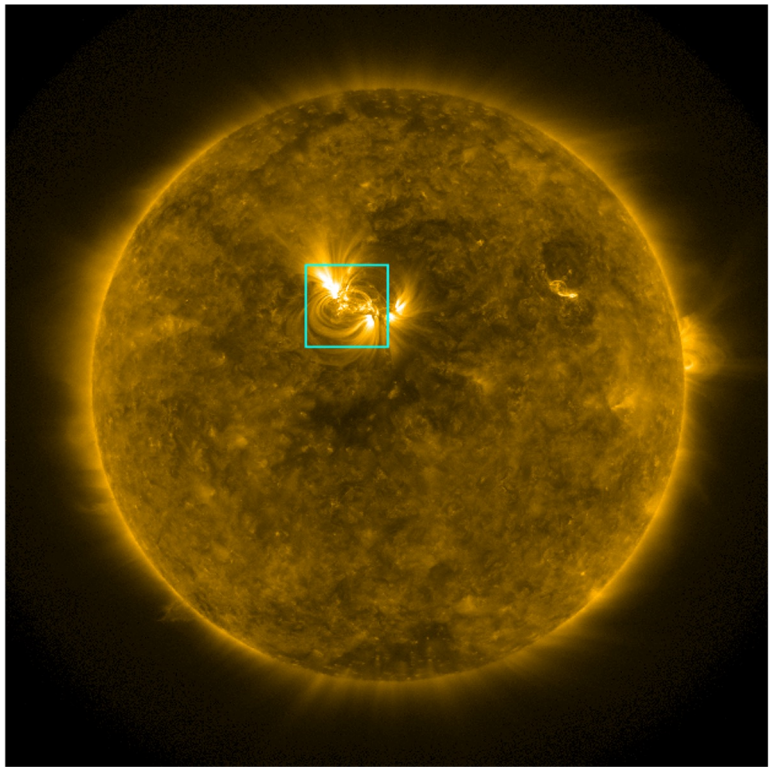

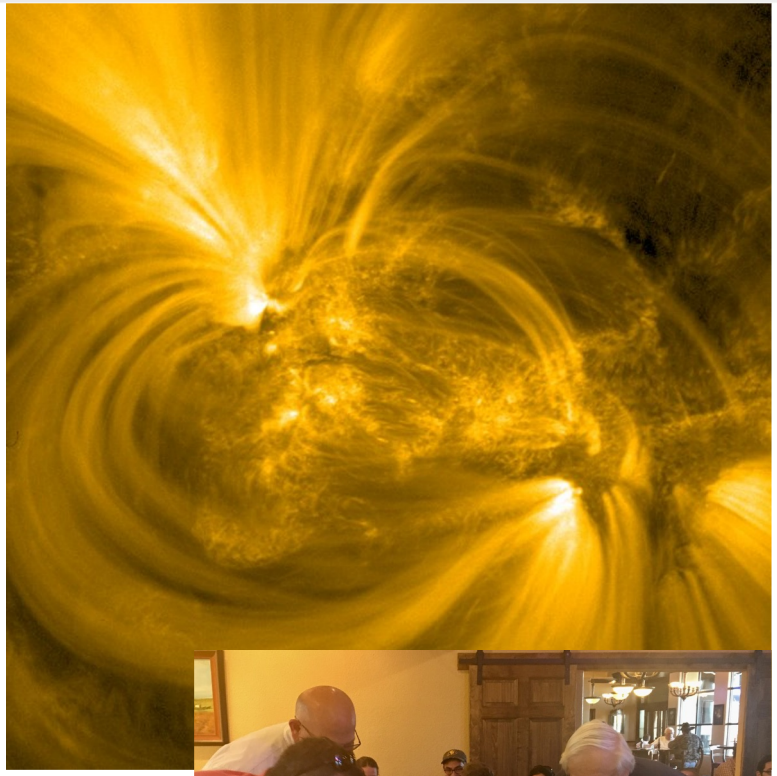

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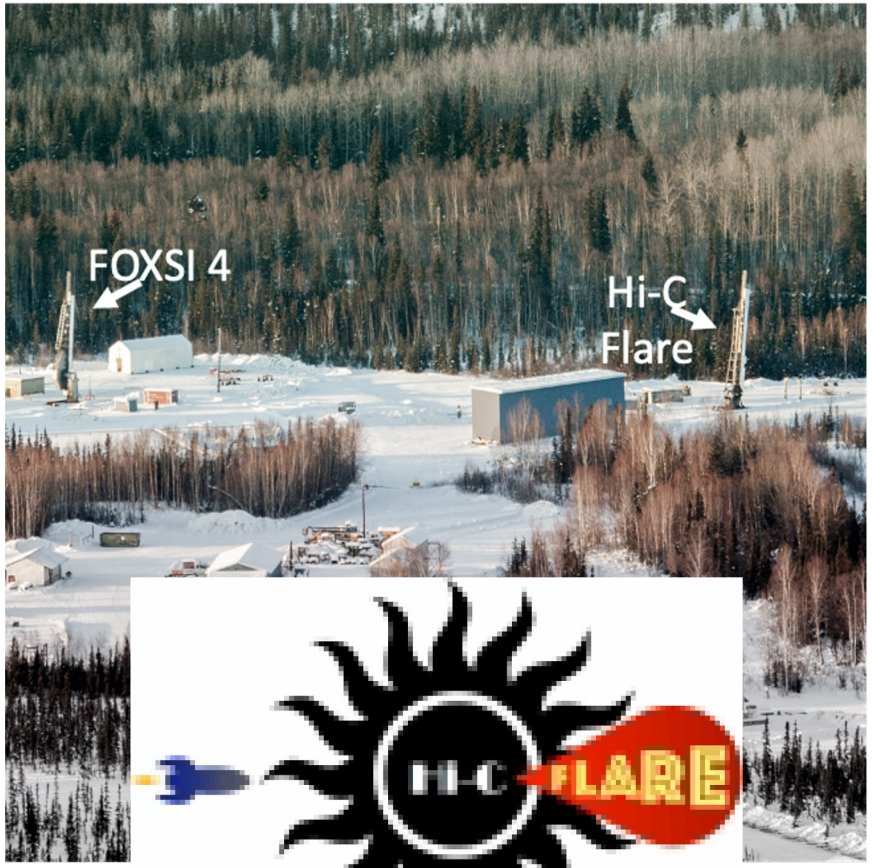
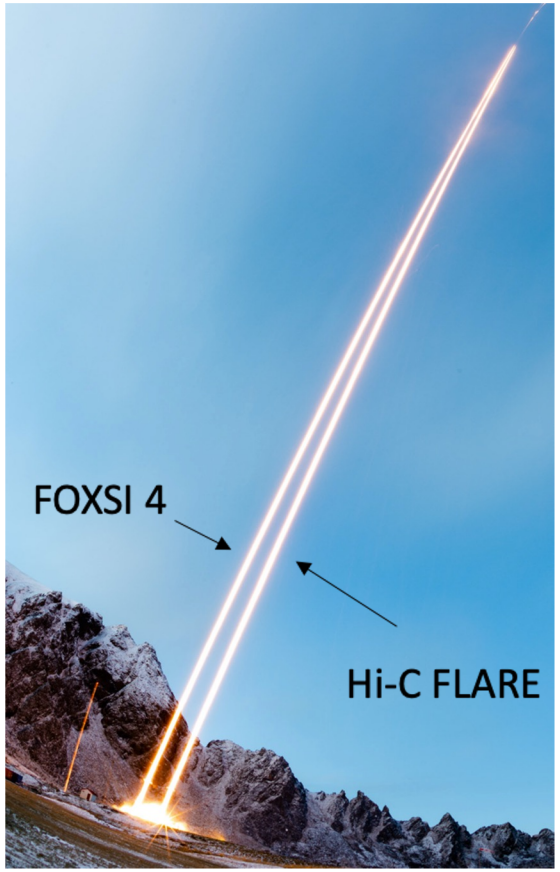




What is the High-resolution Coronal Imager (Hi-C)?

- Hi-C 1 (Cirtain)
  - Flew in 2012
  - 193 passband

~$6M investment
~10 minutes of data

~80 referred publications
~140 non-refereed publications

- Hi-C 2.1 (Winebarger)
  - Flew in 2018
  - 171 passband

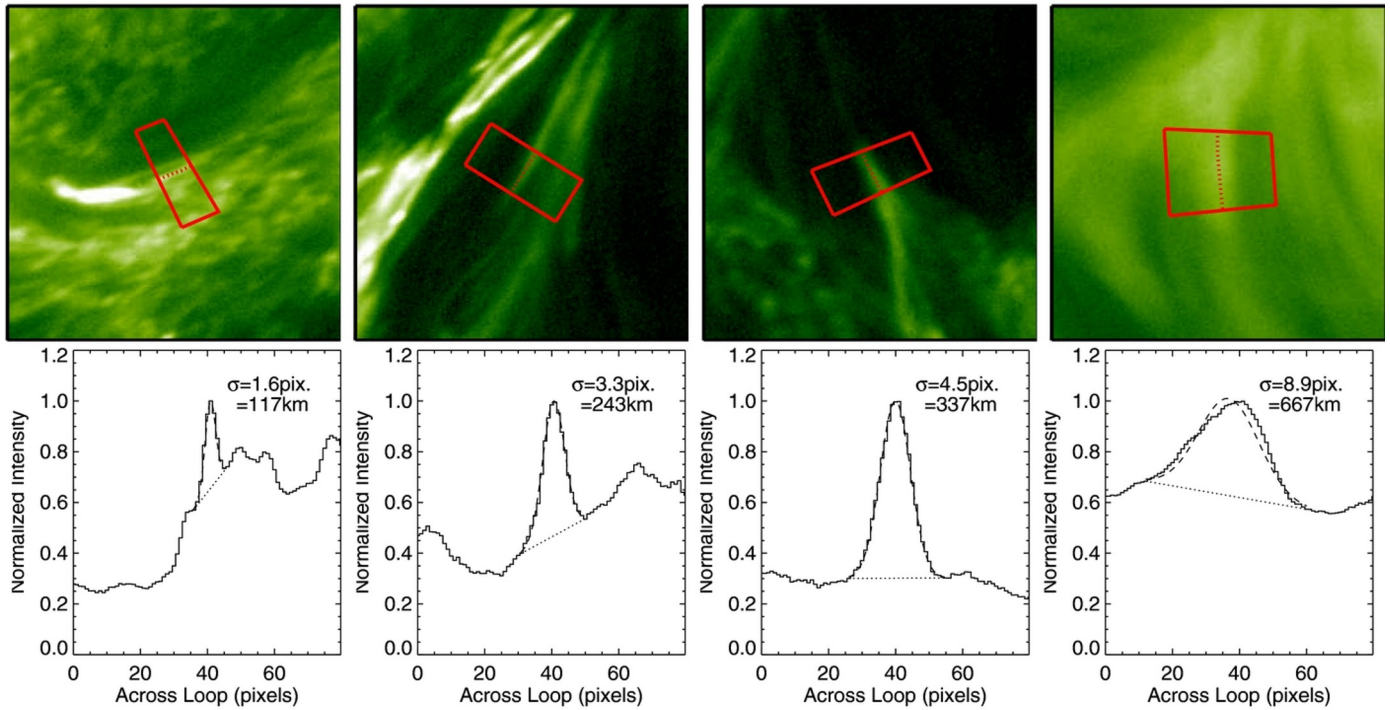
8 refereed publications/minute of data
22 publications/minute of data

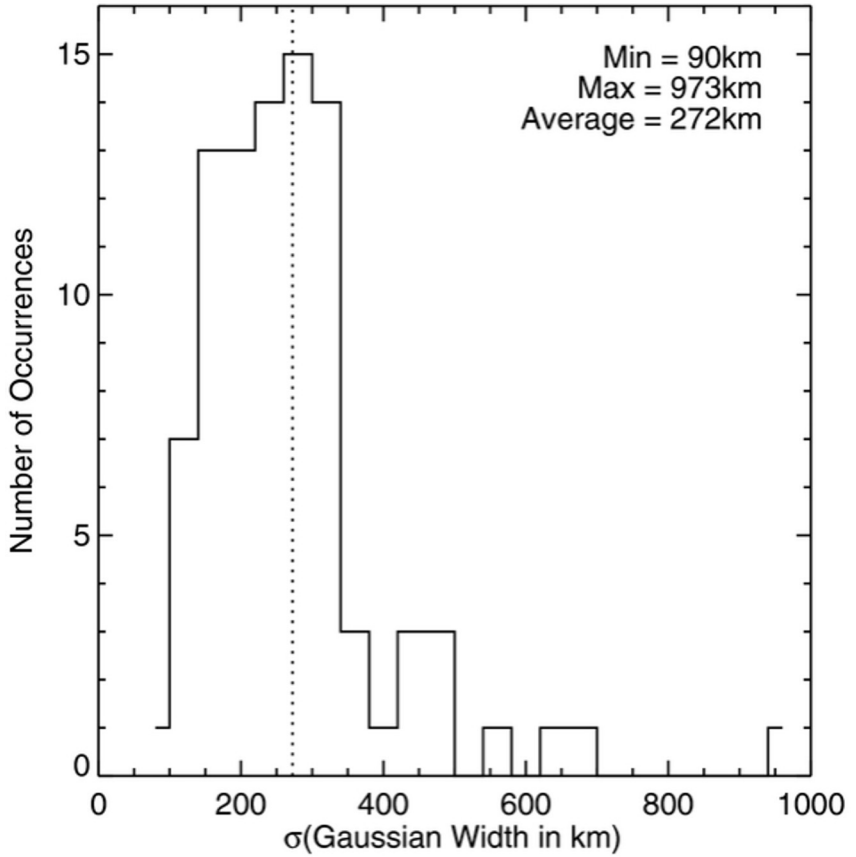
75k/refereed publication
27k/publication

Based on these metrics, Hi-C is the most successful sounding rocket flown in the past 5 decades (maybe ever).

It’s all about the resolution! (But also the cadence.)

- Hi-C has ~0.15”/pix, ~0.3” resolution.
- Hi-C 1 and 2.1 obtained images at 4-5 s cadence.
- Hi-C Flare will obtain images at 1.2 s cadence.





Brooks et al, ApJ, 2013

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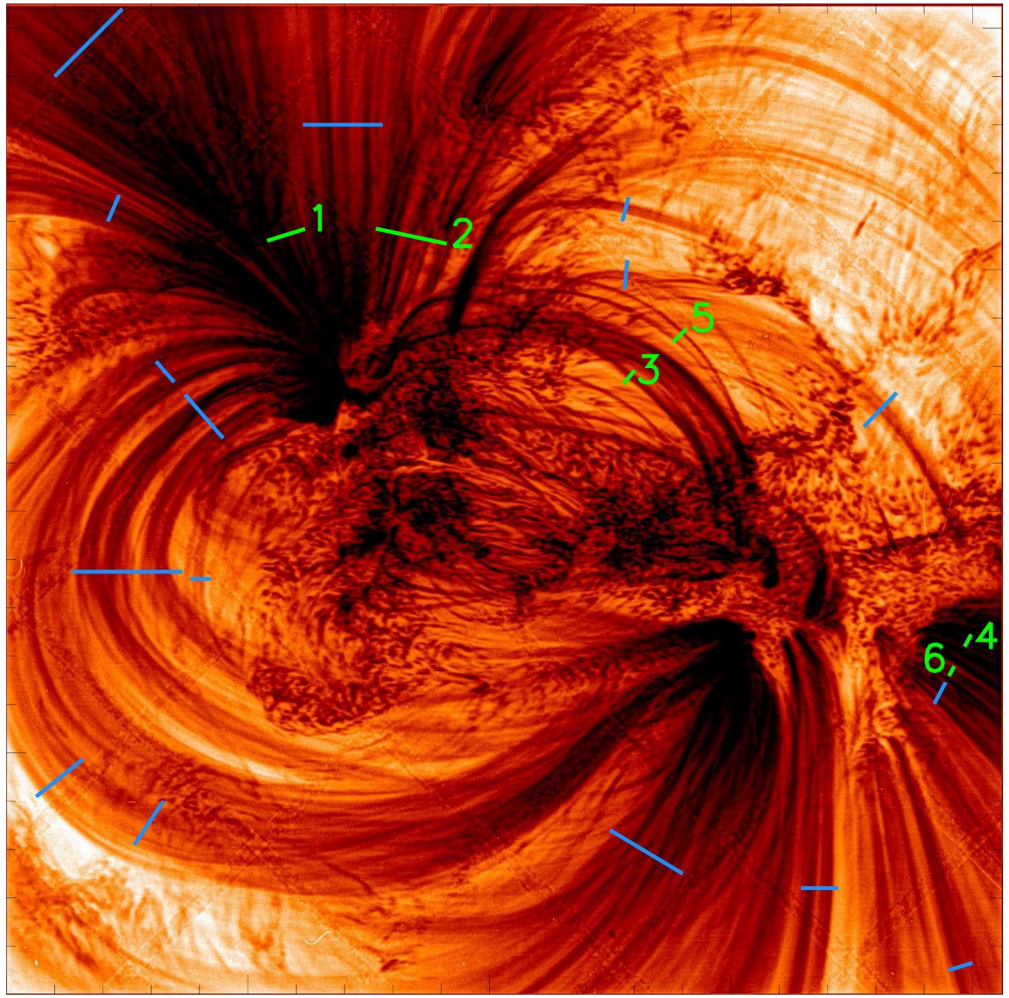

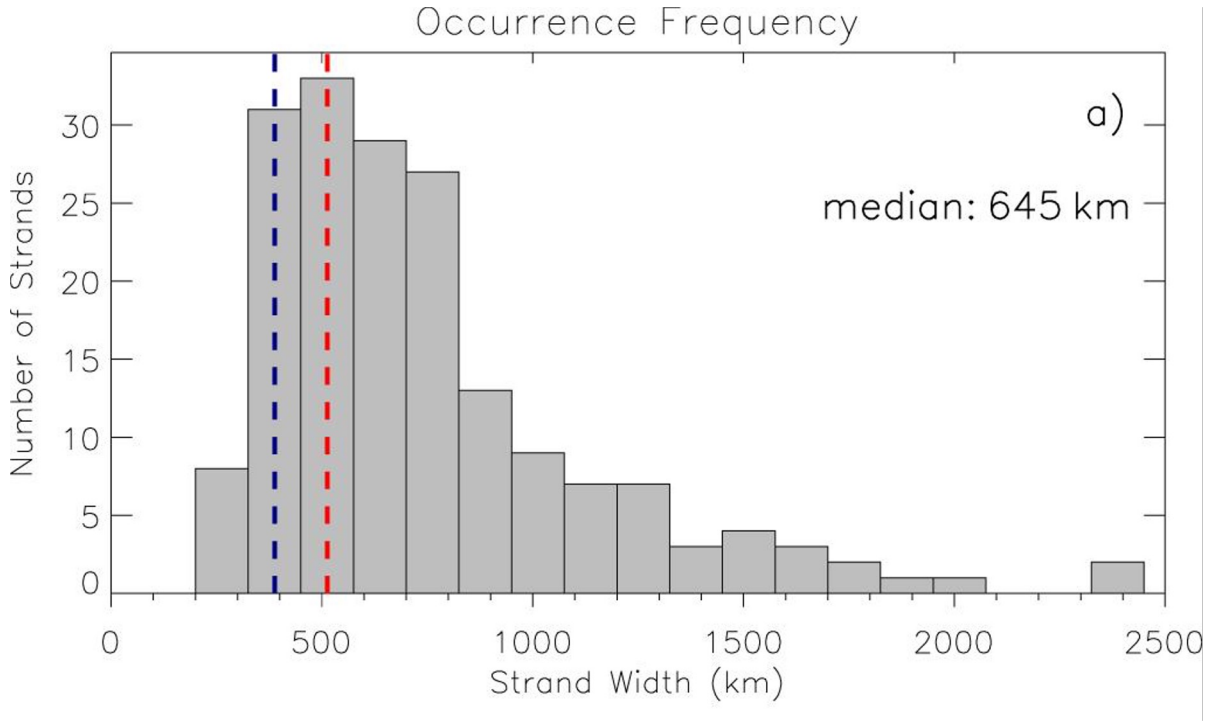

Williams et al, ApJ, 2020

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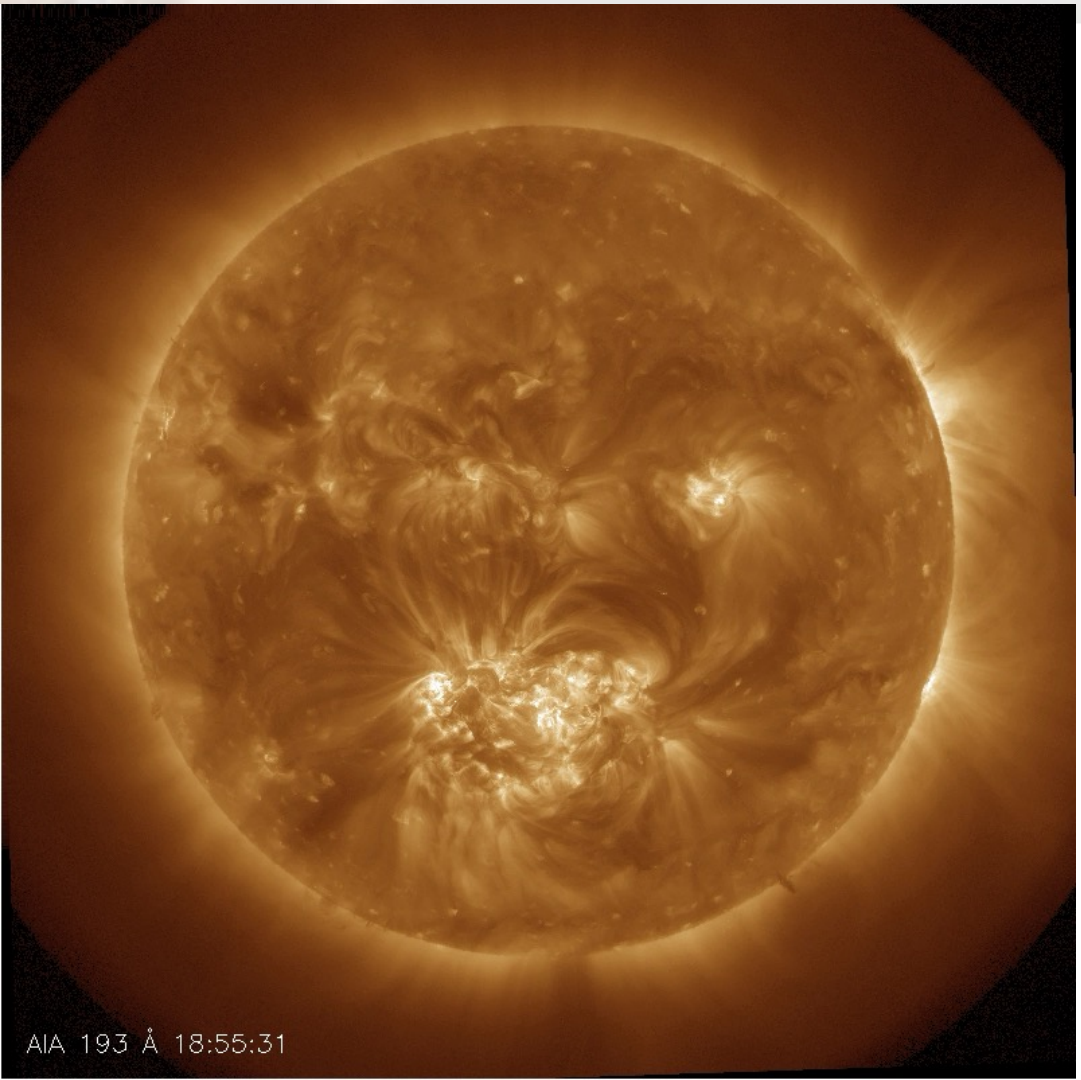
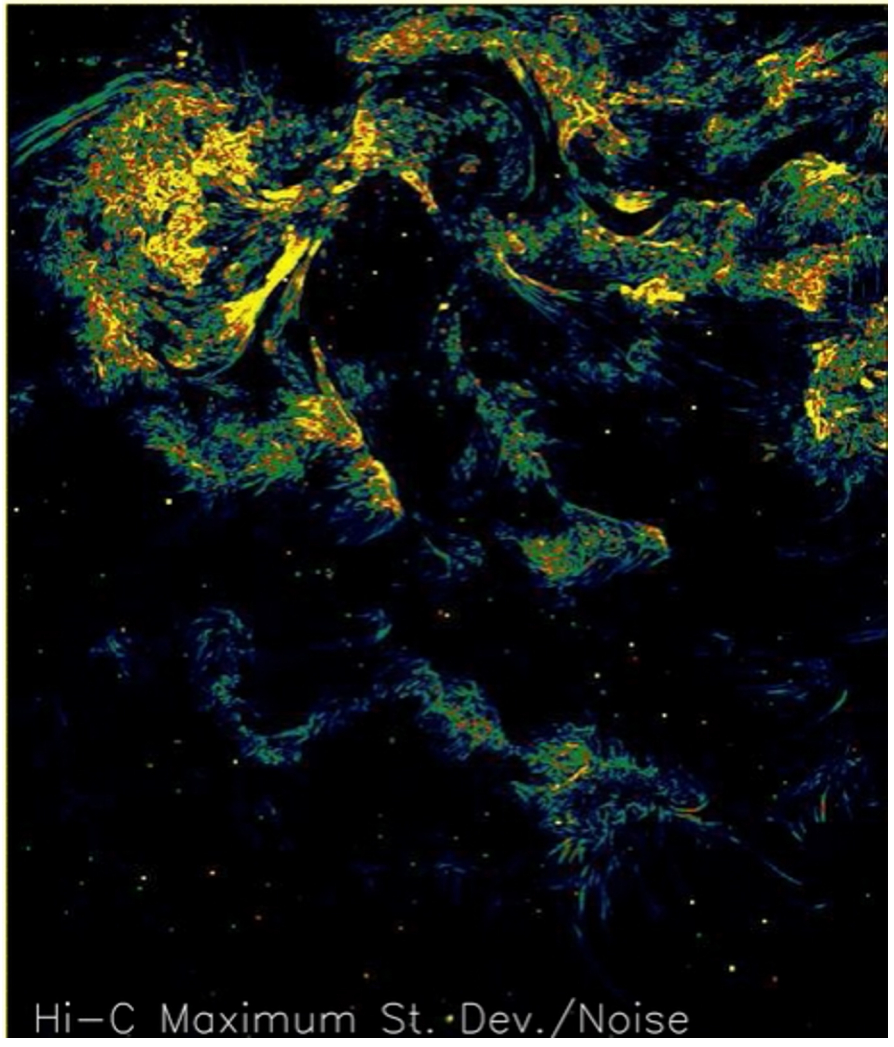
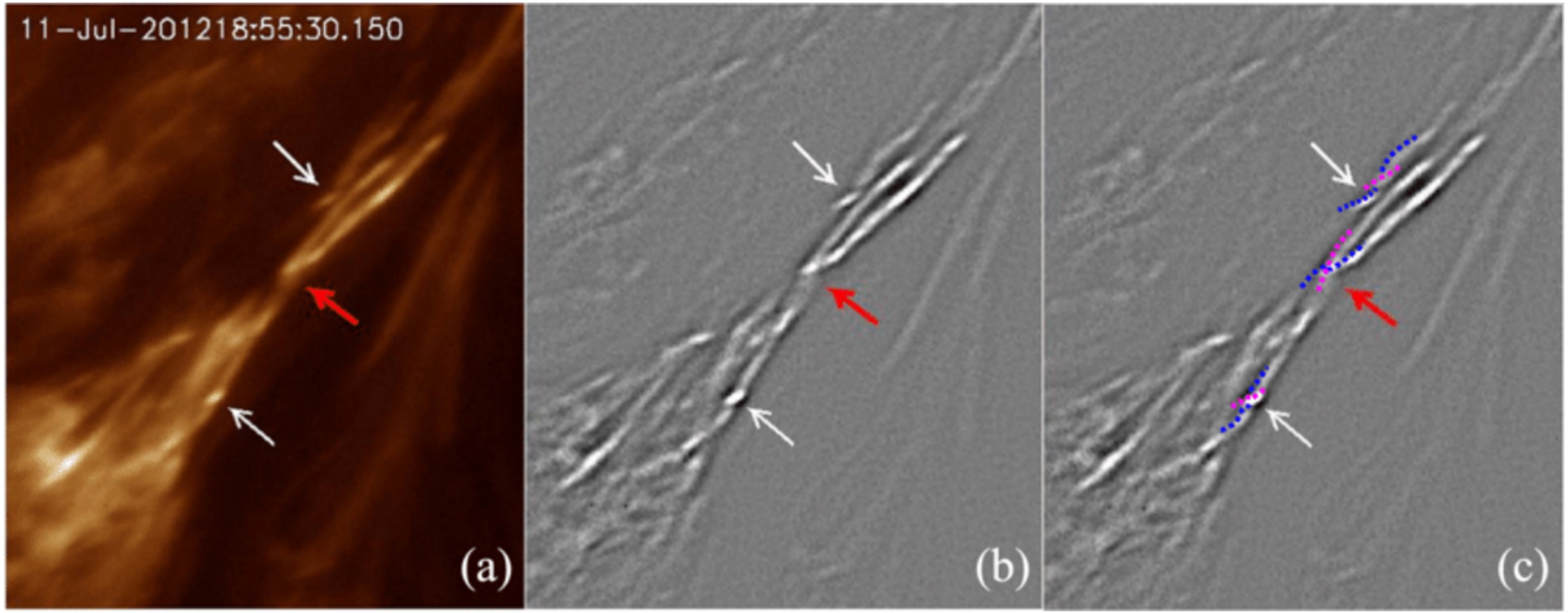




Winebarger et al, ApJ, 2014

Is braiding ubiquitous?



Cirtain et al, Nature, 2013

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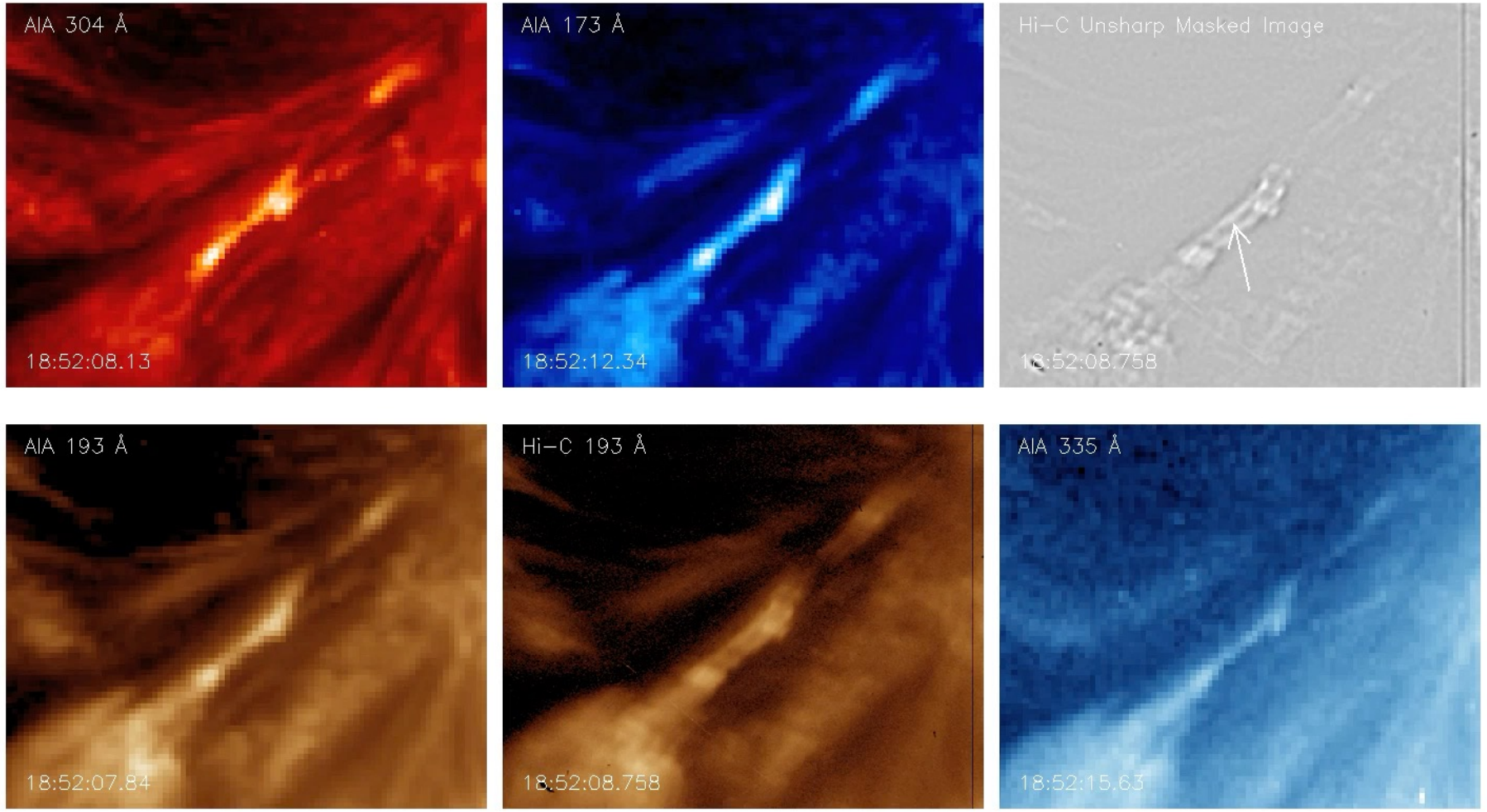
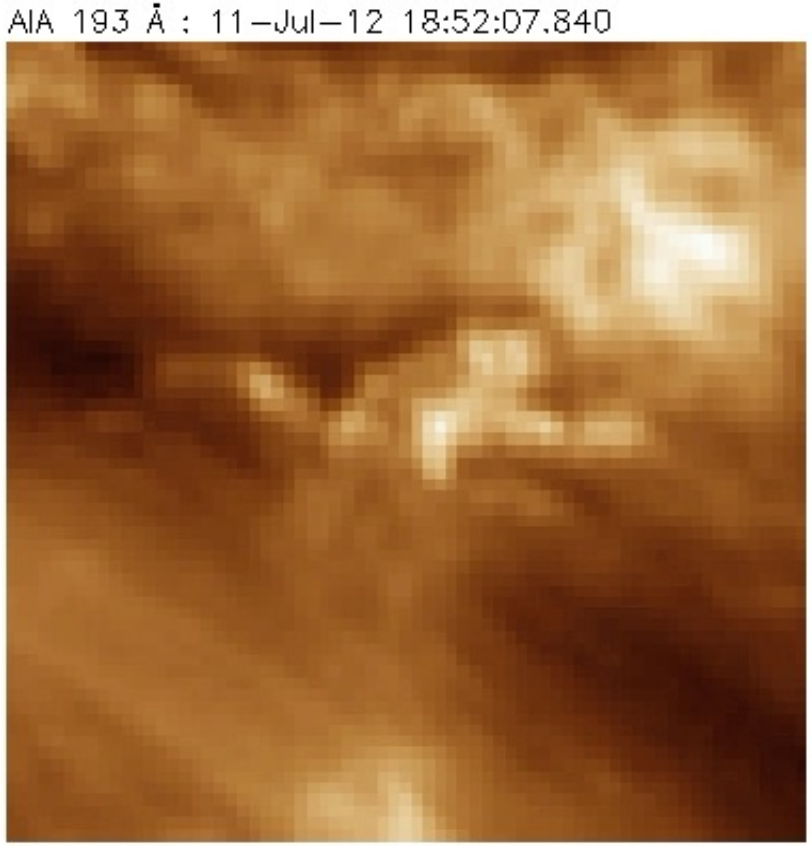
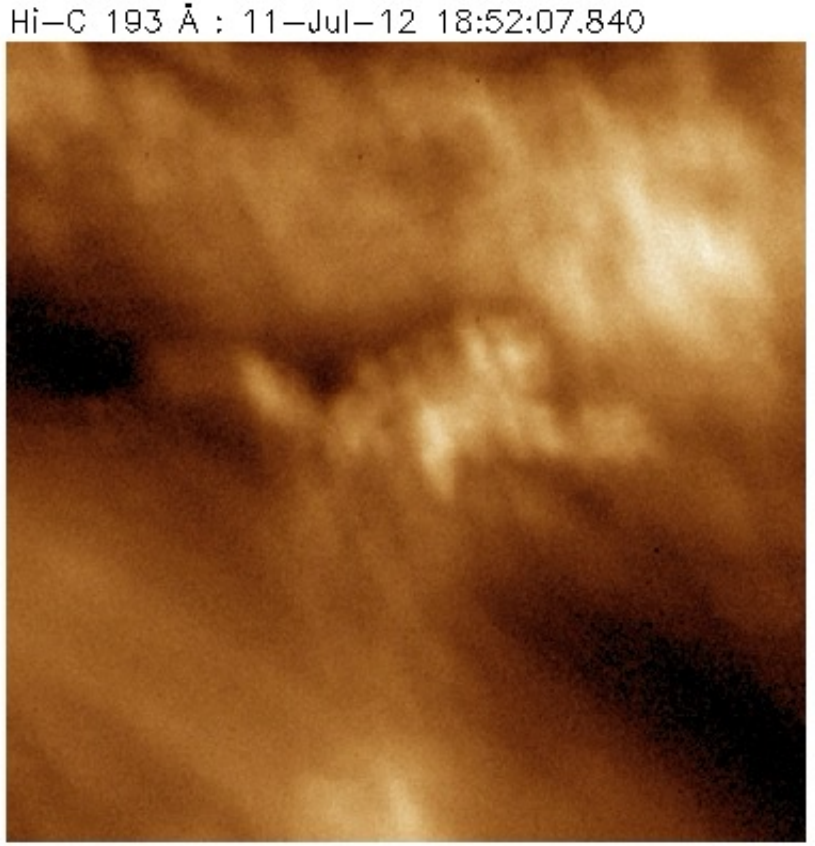


- Is braiding at this spatial scale persistent?
- How do the braids evolve?
- Does it always result in energy release? When?
- Why are the loops bright before the energy release occurs?
- What is the temperature of the structure?

Cirtain et al, Nature, 2013

Where is energy released?



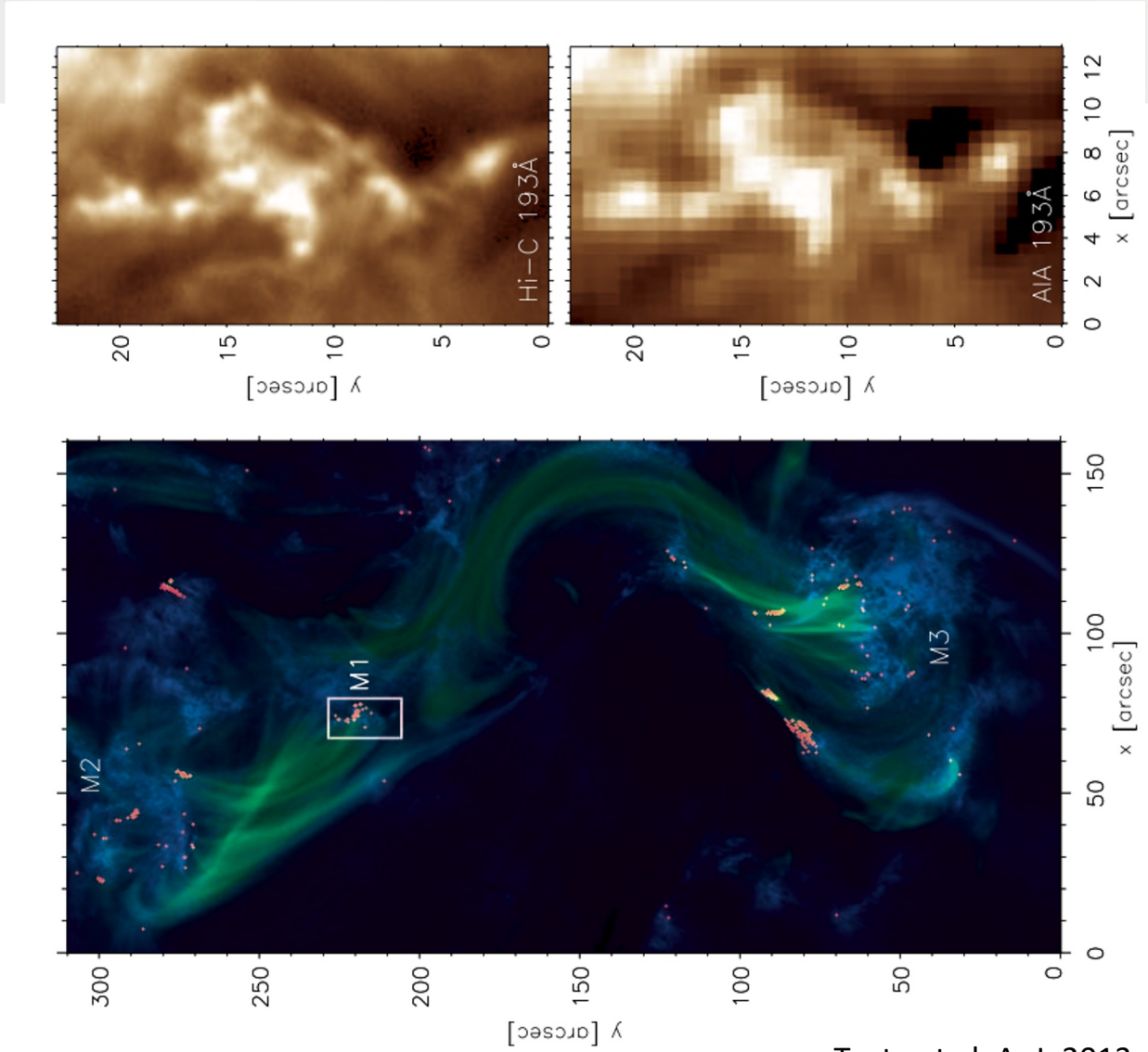


Transition region response provides rare heating diagnostics during conductive cooling

Testa et al, ApJ, 2013

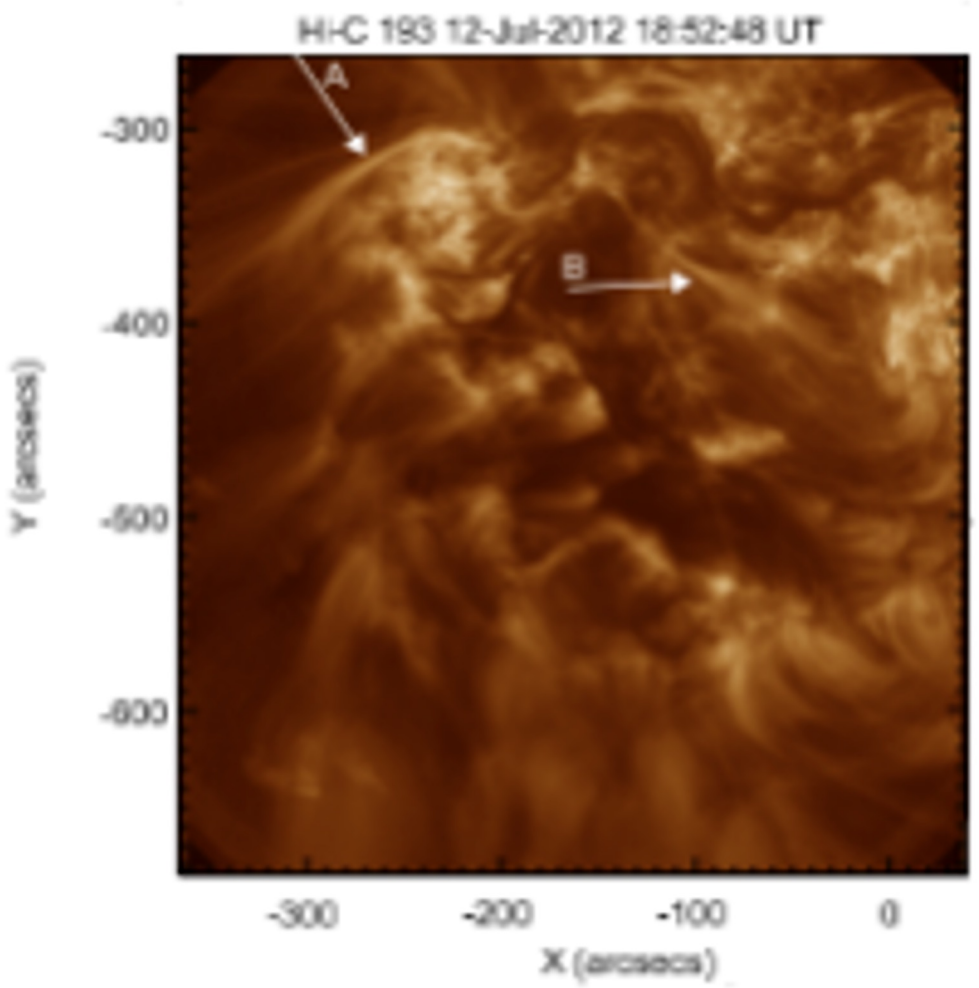
Where is energy released?

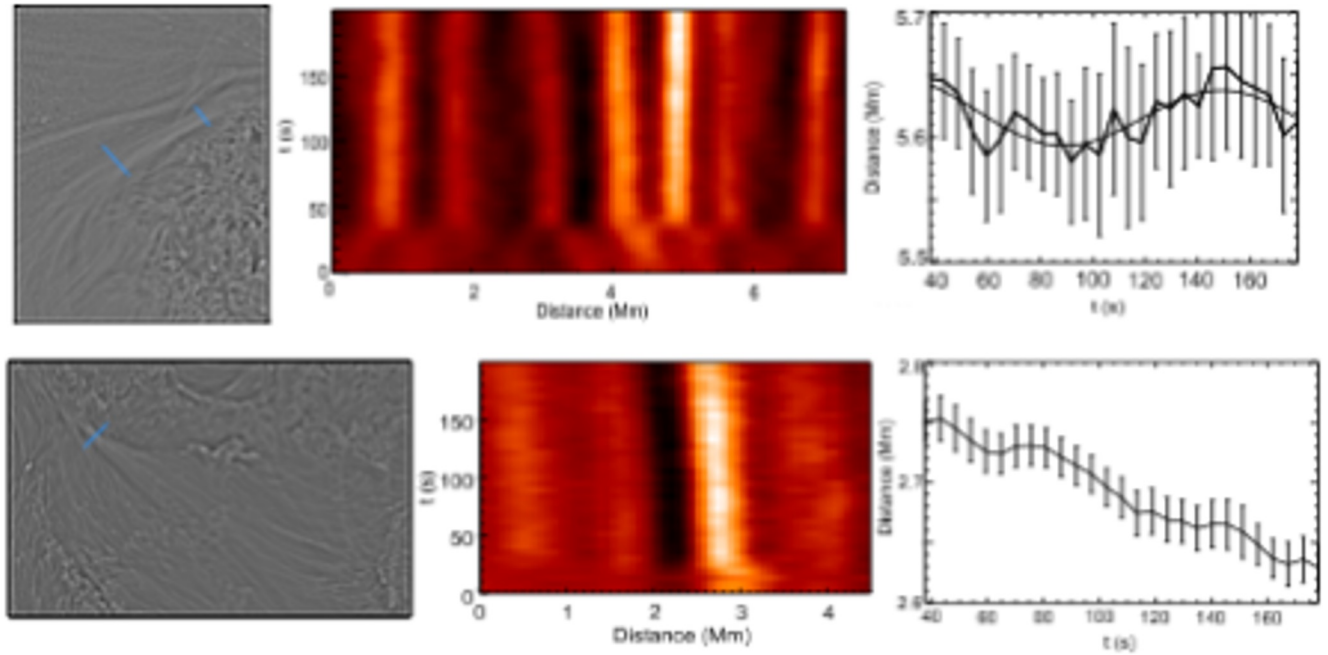
- How frequently energy is released in the corona?
- What does the transition region response tell us about the magnitude and duration of heating?



Testa et al, ApJ, 2013

How much energy is contained in coronal waves?





"[Despite] the five-fold increase in resolution of Hi-C, … the Hi-C data only reveals small-amplitude, low-energy waves and some coronal structures do not show measurable periodic transverse motion even at high resolution."

Morton & McLaughlin, A&A, 2013

Conclusions

Hi-C motivates the spatial resolution for MUSE and EUVST by finding coherence on 0.3” spatial scales.

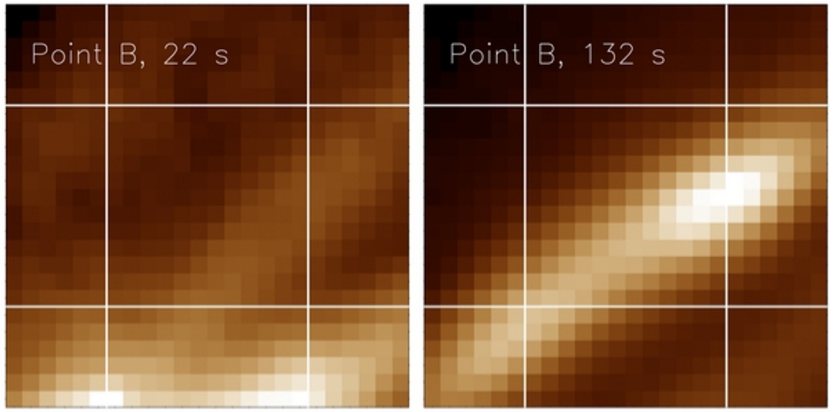
Hi-C has provided a peek into some of the science that MUSE CI can complete with long duration observations.

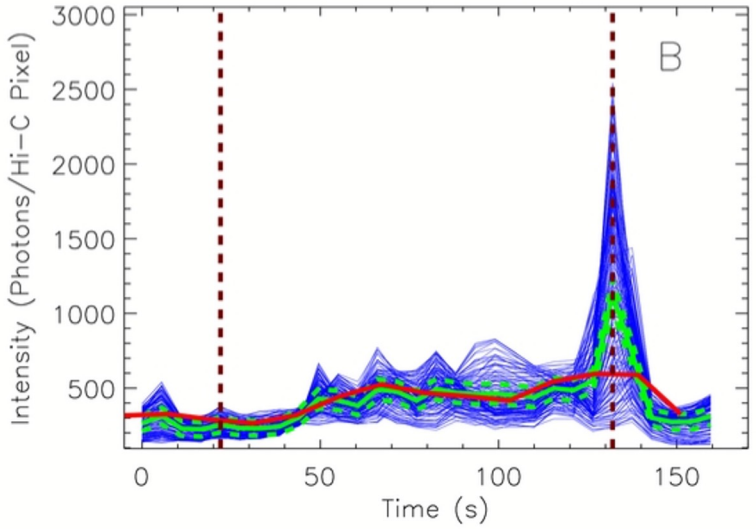
MUSE SP and/or EUVST will enhance these science returns by discriminating the temperature of the structures and providing additional diagnostics.

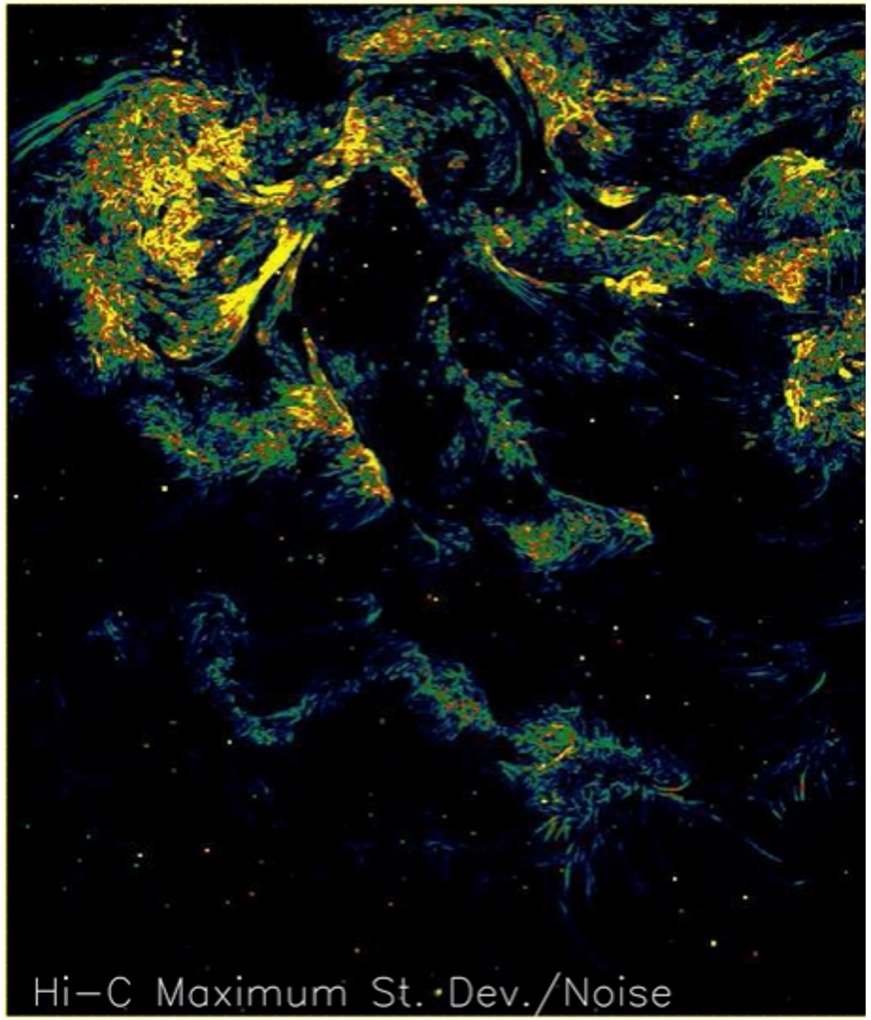
Go Hi-C Flare - March 2024

Back up

Where is the discovery space?







Color = MUSE Discovery Space

Winebarger et al, ApJ, 2014